Utility of Vegetation Indices in Assessing Soybean Canopy Leaf Area

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INTRODUCTION

The yield potential of a soybean crop is related to its canopy leaf area. The leaf area index (LAI) increases during crop development and declines after R5. Canopy closure is necessary for maximum yield potential. Defoliation due to soybean rust can rapidly decrease the canopy's ability to intercept solar radiation.

Vegetation indices (VIs), such as NDVI (Normalized Difference Vegetation Index), WDRVI (Wide Dynamic Range Vegetation Index), and SR (Simple Ratio), quantify the amount of green leaf area. However, they have difficulty detecting differences in LAIs (Leaf Area Indices) after canopy closure.

OBJECTIVE

Our objective was to compare how well the Vegetation Indices (VIs) measured differences in canopy leaf area.

METHODOLOGY

For this study plots were established with different row widths (7.5", 15", and 30") (Figures 1 to 3), which had different times of canopy closure. Canopy closure has been defined as the LAI that achieves 95% light interception (LI).

Vegetation indices, LAI, and LI were measured at weekly intervals from V6 to R5. VIs were measured using a GreenSeeker (NTech Industries) (Figure 4) while LAIs were quantified with a LAI-2000 Plant Canopy Analyzer (LI-COR). LI was determined by simultaneously measuring above and below canopy photosynthetic photon flux density (PPFD) using point and line PAR sensors connected to a LI-1400 data logger (LI-COR).

Fig. 1: 7.5 inch row width plots at V6.

Fig. 2: 15 inch row width plots at V6.

Fig. 3: 30 inch row width pots at V6.

Fig. 4: Crew using the GreenSeeker and taking notes.

The relationship between LI and LAI was described by a third order polynomial regression equation (Fig. 6) with 95% LI at an LAI of 5. WDRVI was calculated from NDVI using a *weighting coefficient* of 0.2 (Gitelson, 2004). These VIs were related to LAI by third order polynomials (Fig. 7) while a linear regression was calculated for SR for LAIs <5 (Fig. 8).

These relationships were used to calculate LAIs for another set of plots. The calculated LAIs were compared with measured values for those plots taken on three sampling dates (Fig. 9 – 11). The SR regression was used to calculate LAIs greater than 5 (beyond its data set range).

A linear regression was calculated for LI vs SR (for LAIs <5, before canopy closure) (Fig. 12).

Gitelson, A.A. 2004. Wide dynamic range vegetation index for remote quantification of biophysical characteristics of vegetation. J. Plant Physiol. 161: 165-173.

RESULTS

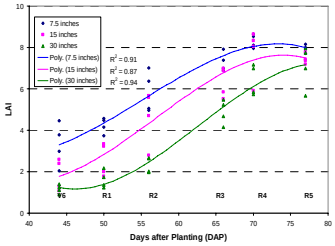

Fig. 5: Canopy development (LAI) of different row widths over time. The regression curves are third order polynomials.

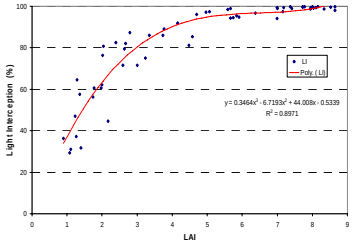

Fig. 6: The relationship between light interception (LI) and LAI as described by a third order polynomial regression curve.

With 95% LI at a LAI of 5, canopy closure occurred at 53, 58, and 66 DAP in the 7.5, 15, and 30 inch row spacing plots, respectively.

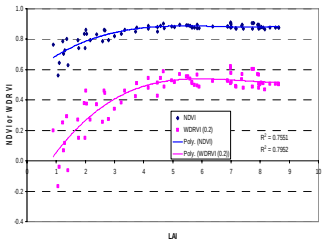

Fig. 7: NDVI and WDRVI (0.2) plotted against LAI and their third order polynomial regression curves.

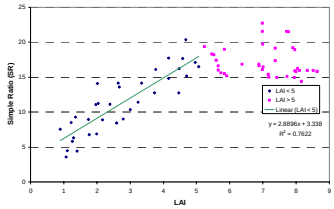

Fig. 8: Simple Ratio (SR) plotted against LAI. The linear regression for LAI values below 5 is shown.

The VI values did not change much for LAIs greater than 5.

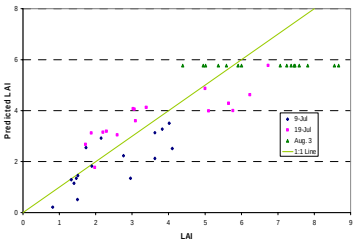

Fig. 9: Predicted LAI (using NDVI) plotted against measured LAI for three sampling dates.

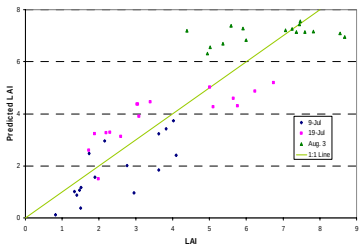

Fig. 10: Predicted LAI (using SR) plotted against measured LAI for three sampling dates.

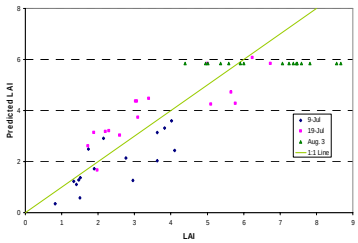

Fig. 11: Predicted LAI (using WDRVI) plotted against measured LAI for three sampling dates.

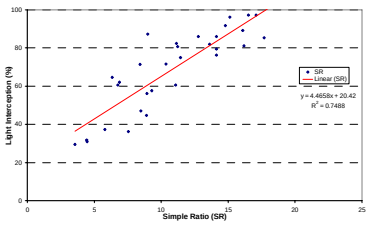

Fig. 12: LI plotted against SR (for LAIs below 5) along with the linear regression.

The predicted LAI values were mostly lower than the measured for the first date (below the 1:1 line), whichever VI was used. For the third date the predicted values were at the upper limit of the NDVI and WDRVI equations. The linear relationship between SR and LI before canopy closure may be useful.

SUMMARY

For this data set, all the VIs tested measured differences in green leaf area before canopy closure. However, they were not very effective after canopy closure. This may not be an issue if the objective is to determine if yield potential may be limited by lack of canopy closure.

Using a relationship calculated with one set of data to predict LAI on another set of plots has limitations. Especially, for LAIs greater than those needed for canopy closure.